Statement of Research

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General Introduction

PhD Degree

I am pursuing my PhD degree at Kansas State University. I have been working in the High Energy Physics Group under the supervision of Professor Tim Bolton, and have been in the CMS collaboration since 2007. As a part of the CMS collaboration I am involved in the efforts of the $V\gamma$ group studying the di-boson production. Analysis for my PhD thesis is the study of the helicity distributions in the $Z\gamma$ production at the CMS experiment. I did most of my research while being stationed at Fermilab, where I benefited from the intelectual recourses of our CMS collaborators.

Masters Degree

I got my master's degree in Solid State Physics at Tbilisi State University for studying the properties of the wide band gap semiconductors (predominantly ZnO, ZnS) and the ways to invert their type of conductivity. I participated in the process of growing wide band gap semiconductor crystals for our research and studying different ways of crystal growth and cutting.

Research Statement

Modern high energy physics experiments are a complicated synthesis of the *theory* behind an experiment, design and development of the *detector* to conduct the experiment, *monitoring* of every detail of the extremely complicated detector, and *analysis* of the obtained data. I am lucky to have worked on various aspects of the CMS experiment. I had an opportunity to work on the pixel detector, develop tools for online monitoring and, of course, do the interesting analysis of the data collected by the CMS.

My *Analysis*

In my analysis I study the di-boson production of neutral gauge bosons and look at the helicity distributions in the data obtained from the hadron-hadron collisions at the LHC. This analysis has not been performed on hadron colliders and it is very interesting for probing the trilinear anomalous gauge couplings. I used the helicity formalism to theoretically calculate the angular distribution of the final state particles (leptons and a photon), for the $Z\gamma$ production, as a result of the quark-quark scattering. Using unbinned likelihood method, for the distribution function obtained, I measure the helicity amplitudes for the particles involved in the process. The helicity amplitudes are very precisely predicted in the Standard Model and any deviation of the measured results from the theoretical predictions could indicate presence of couplings between gauge bosons, which are not allowed by the electroweak theory. Lepton and photon selection criteria has been studied for the $V\gamma$ analysis. Our group is measuring the $Z\gamma$ and $W\gamma$ production cross-section and setting the limits on the anomalous couplings between the gauge bosons. I heavily contributed to the cross-check of the correctness and consistency of the entire chain of analysis in all four channels ($Z(ee)\gamma$, $Z(\mu\mu)\gamma$, $W(e\nu)\gamma$, $W(\mu\nu)\gamma$).

Most exciting part that attracts me to the research in the high energy physics is the search for fundamentally new laws of nature. I know that your group is involved in the top quark physics and searches for beyond the standard model physics involving the top quark. I would be interested in the search for the top-like exotic particles and beyond standard model scenarios involving the top quark. Although precise measurement and analysis withing standard model of the particle that existed in the early age of the universe is not less interesting to me.

WebBased *Monitoring*

My interest in programming and programming languages far precedes their need in my physics data analysis. I have been programming using low level (basic/pascal/C) and later high level (C++/java/etc.) programming languages and developing complicated algorithms starting from my high school years. Software skills enabled me to quickly integrate into the efforts of the WebBased Monitoring (WBM) team. In my projects, I used C++ with ROOT libraries to construct the necessary plots. Java platform and Java servlets were used for publishing the dynamic content on the web pages. Information for the monitoring tools were fetched from different messaging systems and the Oracle database.

I developed web based tools to monitor the performance of the LHC and CMS detector. Tools that enable experts of individual subsystems to have a full, summarized and concise information in near-online regime to quickly gather the vital information and/or respond to the challenges of the detector or other supporting hardware (e.g. vacuum, power supply) or software (e.g. high level triggering). One of my early projects was CMS Page One, which shows current status of the detector and the data collection. Page One is one of the few CMS technical pages that is available for public.

FillReport and *DataSummary* are two of my projects that are very heavily used for Run Coordination and monitoring the vast amount of details of the experiment during each LHC fill and broader period of time. These tools provide vital online, as well as archival, information regarding the CMS and LHC performance. Each summary page provides the possibility to drill down to every detail of every LHC Fill and CMS Run.

My experience in software development and skills acquired during my work on such a big experiment as CMS, makes me confident that I can be a valuable asset in designing and developing challenging software infrastructure for high energy physics experiments.

Hardware Experience - CMS Pixel *Detector*

My first experience with the CMS pixel detector was testing of the detector endcap modules at Fermilab. Later, as a part of the PIRE program, I had the opportunity to have a hands-on experience with the CMS pixel detector at Paul Scherrer Institute (PSI), Switzerland. While working with PSI team, I had a great opportunity to observe and study the detector firsthand. I worked on the commissioning of its barrel part. During testing and commissioning I had hands-on experience with all the details of the detector, architecture of individual modules, digital and analog converters, front-end electronics and software. I developed and optimized software tools (pixelOnlineSoftware, part of xDAQ Software) for testing and commissioning purposes (implemented easy visualization schema for testing, added necessary reset options for the proper initialization of the pixel detector, etc.). After the insertion of the pixel detector into the core of the CMS in 2008 I was very closely working with the pixel detector team to properly calibrate the detector and study its performance.

The biggest challenge during my work at PSI was related to the detector upgrade project. Part of this upgrade is the increase of the digital output size from current 4 bits to 8 bits. I was assigned the task of studying the challenges of simple extension of the current analog to digital converter (ADC) to 8 bits and developing the new possible design. I was able to identify the problem of the 8 bit architecture at hand and probable culprit. To design and test the new ADC I used electronics design software, CADANCE, and started working on possible 8 bit implementation. My 8 bit ADC was utilising the current 4 bit design with addition of the very precise current divider.

Working on the pixel detector was a confidence building experience to tackle the detector related challenges in the future.

Summary

Working in a big collaboration such as CMS increased my team-work skills. In addition, as a major developer and author of my thesis analysis, I acquired very strong skills to work independently. My diverse background in physics and broad experience in the field of high energy physics with the CMS experiment has laid a solid ground for me to pursue academic career. I am very interested in working with your group, and am confident that I can contribute to the efforts of the team, both, in the searches of the new physics and addressing the needs of the experiment by developing the new software tools.